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WOOLLY APHID OF THE APPLE

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BULLETIN No. 217

WOOLLY APHID OF THE APPLE.*

(Schizoneura lanigera)

EDITH M. PATCH.

White masses looking like patches of thick mold often occur on apple trees, especially about pruning wounds or other scars on the trunk and branches and upon water sprouts. Beneath this substance are colonies of rusty colored or purplish brown plantlice known as "woolly aphids" on account of the appearance of white covering which is, however, really composed of waxen filaments.

The species is common in Maine on hawthorn, mountain ash, and Baldwin and some other varieties of apple.

It is one of the migratory aphids and passes part of its life cycle upon the elm**, as is explained in the following treatment. It should not however, be confounded with those woolly aphids found upon alder† and maple‡, as the woolly aphid of the apple cannot live upon those trees.

HABITS AND GENERAL DISCUSSION.

The woolly aphid occurs upon the apple as a bark feeder and is found upon branches, roots, and tender places on the trunk. These insects are covered by a white flocculent waxy secretion given off as fine filaments through pores in the skin

*Papers from the Maine Agricultural Experiment Station: Entomology No. 67.

**There are other elm aphids belonging to this same genus which do not migrate to apple. In order to avoid confusion those are treated in a separate bulletin soon to be published by this Station.

†*Pemphigus tessellata (acerifolii.)*

‡*Pemphigus tessellata (acerifolii)* and *Pemphigus aceris.*

and their colonies are thus readily detected by the masses of white "wool" which renders them conspicuous. Figs. 68, 69 and 78.

On the roots its attacks induce enlargements and in the creases of these malformations the root form occurs in clustered masses. The injury to the trees is due both to the sucking up and exhaustion of the vital plant juices and to the poisoning of the parts attacked, as indicated by the consequent abnormal growths. Fig. 77.

The damage is particularly serious in the case of nursery stock and young trees and is less often important after the tree has once become well established and of some size, though it may be troublesome then, too. Where this insect is abundant all the roots of a young tree to the depth of a foot or so become clubbed and knotted by the growth of hard fibrous enlargements with the results in a year or two of the death of the rootlets and their ultimate decomposition with subsequent disappearance of the galls and also of the aphids, so that after this stage is reached the cause of the injury is often obscure.

On the trunks the presence of the aphids results in the roughening of the bark or a granulated condition which is particularly noticeable about the collar and at the forks of branches or on the fresh growth around the scars caused by pruning, which latter is a favorite location. On the water shoots, they collect particularly in the axils of the leaves, often eventually causing them to fall, and on the tender growth of the stems. The damage above ground, even when insignificant, is useful as an indication of the probable existence of the aphids on the roots. A badly attacked tree assumes a sickly appearance and does not make satisfactory growth, and the leaves become dull and yellowish, and even if not killed outright it is so weakened that it becomes especially subject to the attacks of borers and other insect enemies.

The common forms both on the roots and above ground are wingless aphids, not exceeding one-tenth of an inch in length, of a reddish-brown color, and abundantly covered, especially in those above ground, with a flocculent waxy secretion. Fig. 74.

In August and later, among the wingless ones, winged females appear in abundance. Fig. 73. They are little, clear-winged aphids which look nearly black unless carefully examined when

the abdomen is found to be dark yellowish red or rusty brown. These are the fall migrants that leave the apple and seek the elm before giving birth to the generation of true sexes,—minute, wingless, beakless creatures, the female of which deposits a single "winter egg" within a crevice of the elm bark. I have not yet observed under out-door conditions the return of the fall migrant to the elm, but I have repeatedly during two years observed the spring migration from elm to apple and mountain ash and the subsequent development of the summer colonies so that there is no doubt that the species returns to the elm for the deposition of the winter egg. The flight of the fall migrants away from the apple is apparently a common observation of all who have studied this species either in this country or abroad, with the exception of a statement* that in South Africa, *lanigera* does not produce any alate forms at all in the fall.

Where woolly aphid colonies are very thick, the true sexes and the winter eggs are sometimes found upon the apple tree. That such occurrences are accidental seems probable as fall migrants of most species will occasionally dispose of their progeny before reaching the appropriate winter host.

A record of such an occurrence is to be found in the *Report of the Entomologist of the United States Department of Agriculture for the year 1879* by J. Henry Comstock. On page 259 of this Report, Dr. L. O. Howard recorded his observations made in a little orchard of Russian apple trees then on the grounds of the Department of Agriculture at Washington, his statement concerning the winter egg being as follows:

"The winter egg was found on several occasions during the winter in crevices of the bark over which a colony had been stationed during the summer. It was a rather long ovoid, measuring .322 mm. (.125 inch) in length and was very similar to the winter egg of *Colopha ulmicola* (Fitch), as described by Riley in Bulletin No. 1, Vol. V, Hayden's Survey.

"This egg was laid, as Professor Thomas supposes, by a wingless female, differing from the ordinary agamic form to a certain extent. These females we only know from finding their skins around the winter egg, since they often die without depositing it. The males we have not seen."

Mr. A. C. Baker of the Bureau of Entomology wrote me (Nov. 20, 1912): "I found that when the colonies are very thick the alate forms often stay on the apple and I have found on one tree a number of

*Moore: So. Af. Ag. Journal. Sept. 1912, p. 428.

winged ones with the abdomen shriveled as it is after producing sexes. I saw some sexes crawling up and down the small twigs and though I have not yet seen any eggs which they laid they no doubt would lay eggs. On one occasion I found sexes on an apple leaf which had fallen to the ground."

That such occurrences are not a part of the ordinary life cycle is indicated by the usual wholesale flight of the fall migrants.*

On the elm the stem mother, which hatches from the overwintering eggs sheltered probably in rough crevices of the bark, appears early in the spring and may be found in Maine before the middle of May stationed on the partly opened leaf buds.

The beak punctures on the rapidly expanding new leaves cause an unevenness of growth which forms a protection for the aphid. By the last of May the earliest of these wingless stem mothers are mature and found in the deformed elm leaves (Fig. 70) producing the next generation. The antenna is shown in Fig. 79.

These nymphs, like the stem mother, are a wingless form and they become fully developed about the tenth of June. They have wax glands, of the type shown in Fig. 72. Their progeny are the third generation and attain wings. These winged aphids are known as the springs migrants.

It takes three weeks or slightly more or less, beginning about the twentieth of June, for all the individuals of this third generation to get their growth so that the migration covers a considerable period. The deserted rosette or leaf cluster at this time looks like Fig. 71. During this time these winged aphids may be found alighting on the leaves of apple, mountain ash, and hawthorn. They creep to the under side of the leaf and remain there while they give birth to their progeny (i. e., the fourth generation). These young, before they feed at all, crawl

*1904. Alwood, Wm. B. Circular in Relation to Some Injurious Insects and Plant Diseases. Special Bulletin (C. P. C. 45). Va. Exp. Sta.

1908. Gillette, C. P. Notes and Descriptions of Some Orchard Plant Lice, of the Family Aphididæ. Journal of Economic Entomology. Vol. 1. pp. 306-308.

1909. Börner, Carl. Kaiserliche Biologische Anstalt für Land-und Forstwirtschaft, August.

1913. Reh, L. Der Praktische Ratgeber im Obst—und Gartenbau, February 2.

to the stem of the water-shoots, or to some tender place on the bark often near a pruning wound, and there start the colony on the summer host plant. Such a young colony shown in Fig. 78, was on a mountain ash in Orono of which I kept a record during the season of 1912.

The main trunk of this tree was dead nearly to the ground, but 12 vigorous shoots had grown up measuring about 5 feet each. On June 28 this mountain ash had about 150 woolly masses of nymphs grouped on the stem at the leaf axils. These nymphs ranged from very tiny ones to half grown insects, none being mature at that date. One such woolly mass contained 155 individuals of various sizes. (See Fig. 78). On the ventral surfaces of the leaves of this mountain ash were stationed many elm leaf migrants producing there their broods of nymphs which could be seen, with the hand lens, to be augmenting the woolly masses on the stem. Collections of these migrants thus stationed were made as follows:—July 2, 88 migrants; July 3, 211 migrants; July 5, 92 migrants; July 8, 54 migrants; July 9, 80 migrants; July 10, 33 migrants; July 11, 14 migrants; July 12, 3 migrants. Only living individuals were collected, dead ones being brushed off and discarded in the counts. Microscopic examination showed them to be identical with winged forms collected in elm leaf. Two large elm trees with leaves well stocked with this species stood about a rod distant.*

In this connection it may be of interest to record a forced migration test. On June 21, 1912, I placed several hundred elm leaf migrants at the base of water shoots of an uninfested mountain ash on the Campus. As the migrants are much more docile about sundown than earlier in the day this was done about 7 P. M. They moved but little, most of them creeping to the ventral side of a leaf and remaining there; and during the night producing nymphs which sought the leaf axils of the water shoots so that by the afternoon of June 22, the tiny nymphs had already fed enough and secreted enough white wax to give the typical "woolly" appearance to the young colonies These and the progeny thrived on the mountain ash in a perfectly normal way.

On June 17, 1913, a laboratory cage check was started with migrants from an elm rosette. The winged forms ready to desert the elm leaves were caged with a seedling mountain ash. Their progeny settled in woolly masses on the stem of the seedling and are shown in Fig. 69. By July 2 these had matured and were producing young which in turn had matured and were producing nymphs on July 26. This third mountain ash generation (sixth generation beginning with the stem mother) proved too much for the little seedling which was so nearly dead by August 10 that the last of the aphids perished at that time.

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*Previously recorded in Journal of Economic Entomology, Vol. 5, No. 5, 1912.

The elm leaf aphid which has been here under discussion as migrating to apple, mountain ash and hawthorn is the common elm leaf species making a leaf cluster or "rosette" (Figs. 70 and 71) on the American elm, composed of terminal leaves more or less bunched together. This species is found in Maine, Missouri, Colorado and doubtless all the way between. Like other aphids it is fluctuating in its abundance, being conspicuous everywhere some years and comparatively rare during other seasons.

Fig 67 shows a different type of leaf deformation common on elm which is designated as "leaf curl" or "roll". Three different species of aphids belonging to the same genus (*Schizoneura*) produce this type of pseudogall in America.* One of these elm leaf curlers migrates to apple; another appears to be the English species which migrates to the roots of currants and gooseberries; and the destination of the third is at present unknown. The second and third species will be treated in further detail in a separate bulletin, this paper being concerned only with the elm-apple aphids.

Whether the leaf curler which migrates to apple is a distinct species from the form which inhabits the rosette, I am not at present prepared to state. The apterous viviparous generations have the same general type of wax glands (Fig. 72), the winged generations accord in characters.

It seems quite possible that under different conditions (as weather or the size or position of the leaf attacked) that the same species might produce two types of elm leaf deformation. However that may be it was Missouri migrants from such leaves as the one shown in Fig. 67 that gave me my first successful transfer test under control conditions.

Through the kindness of several southern entomologists, elm leaf curl in considerable abundance with winged forms ready for migration was secured in May, 1912, thus lengthening the season for purposes of experimenting. These migrants, as previously explained (Science, Vol. 36, pp. 30-31), were caged over apple seedlings greenhouse-grown for the purpose, the seeds having been planted in December 1911 and January 1912. A few very successful colonies of woolly aphids were thus established on apple seedlings by the progeny of the elm migrants, the earliest of which was one started by migrants received May 12. (Fig. 68). The fall migrants of this colony were mature and taking flight September 20-23.

So far as I am at present able to judge, the progeny of these migrants from leaf curl and the progeny of migrants from rosette both look and behave identically alike. Certainly if they prove to be distinct it will

*Since Bulletin 203 went to press last year, significant collections both from Maine and other parts of the country have come to my attention which have added much to our knowledge of these species concerning which much still remains to be learned.

be a difficult problem to decide which is *lanigera!* The other two leaf curlers, however, are certainly distinct.

There are apparently 3 summer generations of progeny of the elm leaf migrants upon the apple in Maine,—two apterous generations followed by a generation part of which, the fall migrants, become winged and leave the apple and part develop into apterous forms and remaining on the apple give birth to nymphs which while still young seek protection at the base of the tree for the winter and are known as the hibernating nymphs.

It is the function of the migrants to seek the winter host and there give birth to the true sexes. These are the tiny yellowish brown egg-laying females and the still smaller pale yellow males. Both sexes are wingless and with rudimentary mouth parts which are apparently functionless. One comparatively large yellow egg occupies nearly the whole abdomen of the female and with the deposition of this the cycle of the species closes,— or begins. It is too complicated a performance to follow easily but the outline on page 182 will be useful as a summary. Such a cycle with the annual migration to and from the apple with the elm serving as host for the first three spring generations is undoubtedly typical for *lanigera*. The hibernating nymphs which remain protected about the crown of the apple over winter and ascend to tender places on the bark before feeding in the spring give what looks like a "closed cycle" of apterous viviparous females persisting on the apple. How long such a colony could maintain itself on the apple without fresh material from the elm I do not know.*

I am certain that in Maine the natural enemies of the woolly aphid would cut its career short and that it would not assume the status of a pest of consequence if it did not shift its food plant. As it is, a two days quest in the vicinity of Orono early in September 1913 failed to locate a single colony which was not well nigh demolished by Chalcid parasites and the colonies of

*We have an exact parallel in *Pemphigus tessellata* or the woolly aphid of the alder with a cycle including a spring migration from the maple leaf to alder and a fall or return migration to the maple and also a generation of hibernating nymphs remaining under leaves about the base of the alder during the winter and ascending to the stem before feeding in the spring.

1912 met a similar fate the preceding year by virtue of Syrphus maggots. Lady bird beetles are also very active some seasons. While in the elm leaf this aphid is preyed upon by Syrphus maggots, Capsid bugs and lady birds.

As if the hibernating nymphs were not enough to bewilder one, the case of the woolly aphid of the apple is still further complicated by the root colonies which although hidden in their operations really are often much more pernicious than the colonies on trunk and branches. These root colonies ordinarily remain underground all the year round, apparently until the roots become too badly demolished for feeding purposes.

Economic Status.

The danger from the woolly aphid is greatest to nursery stock and young orchards. Mr. Marlatt (Journal of Economic Entomology, Vol. 4, pp. 116-117) in recording the use of American-grown apple seedlings says:—"Mr. F. W. Watson, of Topeka, Kans., in an article in the *National Nurseryman* for January, 1910, p. 437, on 'American-grown Apple Seedlings', states that from twenty to forty million of American-grown apple seedlings are used in this country every year, the production of about a dozen nursery firms. The bulk of the seed used comes from France, and therefore is of the same stock as the imported French seedlings."

Mr. Lohrenz (1911) in recording observations on two-year-old nursery stock made at three nurseries containing respectively about 30,000; 45,000; and 300,000 trees, states that he found from 20 per cent to 25 per cent of the trees infested by the woolly aphid.

In circular No. 20, Bureau of Entomology U. S. Department of Agriculture (revised edition 1908) the woolly aphid of the apple is characterized as "one of the worst enemies of the apple."

Mr. Alwood (1904) of the Virginia State Crop Pest Commission in his excellent account of this insect states "On nursery stock the woolly aphis is a most serious pest, and under some circumstances it ruins a large percentage of the apple trees in the nursery."

On page 5 of Bulletin 133 of the Colorado Experiment Station the following statement is made:

"If Colorado orchardists should vote their opinion as to what ought to be called the worst orchard pest in the state, it is very doubtful whether the codling moth, or the woolly aphids, would carry off the honors."

Although it would be easy to compile testimony of this character against the woolly aphid as an enemy to young apple trees from numerous and widely separated parts of our country, they would be chiefly a repetition of what has already been said.

During those seasons when the species is abundant it is also a serious pest on American elm. Some springs in the vicinity of Orono practically every branch of many trees is tipped with an unsightly cluster of deformed leaves or "rosette" gall. Such an infestation, to say the least, mars the beauty of a large tree and is a heavy handicap for a young one.

LIFE CYCLE OF WOOLLY APHID OF APPLE.

(Exclusive of root forms.)

ELM: Primary Host.	APPLE: Alternate Host.
EGGS. (Under bark all winter)	NYMPHS. (Hibernating young, migrating to trunk or branches in early spring)
STEM-MOTHER. (first generation in leaf. Apterous viviparous females).	
SECOND GENERATION. (apterous viviparous females in leaf)	SEVERAL GENERATIONS.
SPRING MIGRANTS (third generation. Alate viviparous). Migrate to apple →	FOURTH GENERATION. (apterous viviparous females).
	FIFTH GENERATION. (apterous viviparous females).
Migrate to elm ← FALL MIGRANTS. (Alate viviparous parthenogenetic females, mature Aug.-Sept. sexuparae.)	APTEROUS VIVIPAROUS PARTHENOGENETIC FEMALES, mature in Aug.-Sept.
APTEROUS OVIPAROUS FEMALES AND APTEROUS MALES.	
EGGS. (under bark all winter).	HIBERNATING NYMPHS (protected during winter about crown of tree).

STRUCTURE KEY.

Woolly Aphid of Apple.

A. Apterous forms. Antennae without annulations.

B. Females.

C. Viviparous.

D. Antenna typically 5-jointed, Fig. 79. Wax glands not of type shown in Fig. 72. First spring generation hatched from over-wintering egg and found in elm rosette early in June .....*Stem Mother.*

DD. Antenna 6-jointed. Fig. 80. Wax glands as shown in Figs. 72 and 80. Progeny of stem mother developing in rosette in June .....*Second Elm Generation.*

DDD. Antenna 6-jointed. Fig. 82. Wax glands of same type as those shown in Fig. 72. On apple bark or water shoots .....*Summer Generations.*

DDDD. Structure about as with summer generations. On apple roots all times of year.....*Root Generations.*

DDDDD. Young born late in fall and living over winter about crown of tree, apparently without feeding until spring, when they ascend to apple bark and attain their growth .....*Hibernating Nymphs.*

CC. Oviparous.
Antenna 5-jointed, Fig. 75. Minute beakless form which deposits the over-wintering egg. Rarely seen but easily obtained by imprisoning fall migrant in vial..*True Female.*

BB. Minute beakless form smaller and more slender than true female. Antenna 5-jointed. Fig. 76. Rarely seen but easily obtained by imprisoning fall migrant in vial.....*True Male.*

AA. Alate forms. Antennae with annulations.

B. Antenna typically with III as long as or longer than IV+V+VI. VI typically without annulations. Fig. 81. Developing in June-July in elm rosette and migrating to apple, hawthorn and mountain ash. Progenitor of summer generations.....
.....*Spring Migrant.*

BB. Antenna much as in spring migrant, though usually shorter. VI typically with 2 or more annulations. Figs. 83, 84, 85. Developing in fall in woolly colonies on bark of apple, hawthorn and mountain ash. Fig. 73. Progenitor of true males and females .....*Fall Migrant*

HABITAT KEY.

Woolly Aphids of the Elm.

Those species not migrating to apple are to be treated in a separate bulletin but a key is given here to aid in distinguishing the woolly aphid of the apple from the other elm species with which it may easily be confused in the spring of the year.

A. Conspicuous woolly colonies on bark of *Ulmus americana*. Throughout the summer on young elms. No alternate host known. Widely distributed in America. .....*S. rileyi.*

AA. Spring generations in elm leaves, causing various types of deformation.

B. Large baggy gall on *Ulmus campestris*. Alternate host unknown. European species. Taken in Connecticut in 1913..*S. lanuginosa.*

BB. Terminal leaf cluster or rosette (Figs. 70-71 on *Ulmus americana*. Spring migration to apple, mountain ash, and hawhawthorn. Maine to Colorado..... .....*S. lanigera* (*americana* in part, of authors).

BBB. Leaf curl or roll type of deformation.

C. Leaf roll as shown in Fig. 67. Wax glands of apterous generations and antennae of winged generations apparently the same as those of the rosette dweller. Spring migration to apple. Recorded as yet only from the south..... .....*S. lanigera* (*americana* in part, of authors).

CC. Leaf roll of *Ulmus scabra* and *U. campestris*. Antenna of winged generations with V and VI without annulations. Spring migration to gooseberry and currant. European species. In America found in California, Oregon and Maine (1913).....*S. ulmi* (*fodiens*).

CCC. Leaf roll of *Ulmus americana*. Second apterous spring generation with wax gland distinctly unlike those of Fig. 72. Spring migrant with antenna typically with III not longer than IV+ V+ VI. Alternate host unknown. Maine to California.....*S. americana* in part, of authors.

Preventive and Remedial Measures.

The foregoing account of the habits and characteristics of the woolly aphid will suggest certain measures to control it.

The protection of seedling apples from infestation by the woolly aphid while still in the nursery has heretofore been an exceedingly difficult matter it would seem from the amount of infested stuff that is yearly condemned. But with the knowledge that the source of danger lies in the migrants from the previously unsuspected elm leaf, it is seen to be possible to control the nursery stock by establishing nurseries at a safe distance from susceptible elm trees or clearing out the elms from the vicinity of large nurseries. As there are many places in the country where the elm is not at all abundant this would often be entirely practicable and where so would be the simplest and most effective method of protection. As it is the seedling trees that are most susceptible to injury and when attacked most seriously damaged by the woolly aphid a method of protection for the young trees while in the nursery is the most desirable.

The raising of the elms and apples in the same nursery is thus seen to be a hazardous proceeding and should be avoided.

Again young orchards of clean stock set in parts of the country where the elm is not grown should be successfully protected by excluding elms from the choice of shade trees. Indeed, the matter of alternate hosts of the aphid enemies concerned should always be borne in mind in planning the trees for an estate, and only one of the two hosts necessary for the life cycle of a migratory aphid planted, where the pest is a serious one.

It is desirable that data concerning the relative susceptibility of different varieties of apple should be accumulated with a view to using the more resistant for root stock, if otherwise practicable.

In dealing with infested apple trees the aphid masses on trunk and branch present no especial difficulty, and can be very readily exterminated by the use of any of the washes recommended for plant-lice, such as tobacco decoction, kerosene emulsion, a strong soap wash (Formulas a, b, c, d), the only care necessary being to see that the wash is put on with sufficient force and thoroughness to penetrate the covering and protecting cottony secretion. If the wash be applied warm, its penetration will be considerably increased.

An August spray to kill out colonies before the migrants fly and the hibernating young are produced is particularly desirable.

The much more important root feeders, however, are more difficult to reach and exterminate. The common recommendations are of applications of strong soap or tobacco washes to the soil about the crown, or soot, ashes, or tobacco dust buried about the roots; also similarly employed are lime and gas-lime.

Badly infested nursery stock should be destroyed, since it would be worth little even with the aphids removed.

Some nurseries are said to make a practice of "puddling" roots of infested stock, that is packing mud about the roots to conceal their condition. Before purchasing puddled nursery stock, the buyer should insist that the mud be washed off thoroughly so that the roots are exposed for inspection.

Proper cultural methods can hardly be overestimated in their value as a protection of young trees, as neglected orchards not only suffer heavily but serve as a breeding ground, dangerous to the neighboring trees.

FORMULA A—TOBACCO DECOCTION.

Tobacco stems or tobacco dust	2 pounds
Water	4 gallons

Put the tobacco in the water, enough to cover, which may be either cold or hot. Place over the fire and when the water has reached the boiling point, remove some of the fire and allow the water to simply *simmer* for fully one hour, when the liquid is ready to be drained off, diluted to the above proportions and applied. Boiling violently drives off the nicotine.

If whole-leaf tobacco is used, prepare as above, using one pound of tobacco to each four gallons of water.

No lime or other alkaline substance should be added to the tobacco *while cooking*. Apply at once, or within a few days after making if possible.

Certain reliable extracts such as *"Black Leaf," "Black Leaf 40,"* and *"Nikoteen"* are on the market and can be secured through local druggists. (The Black Leaf preparations are manufactured by *The Kentucky Tobacco Product Company*, Louisville Ky., and are carried by the Collins Hardware Company, 97 Friend St., Boston, Mass. *Nikoteen* is manufactured by The Nicotine Manufacturing Company, St. Louis, Mo., and can be secured from Joseph Brick & Sons, 47-54 N. Market St., Boston, Mass.).

Directions for use come with the products. There is nothing to do in the preparation of these extracts except to stir the contents of the

can before pouring out any quantity for dilution. In most cases one gallon of the *Black Leaf* will be found sufficient for each seventy gallons of water. But if in the treatment of any louse this does not seem sufficient it may be used in preparation of one gallon to sixty or sixty-five gallons of water. Careful sprayers have usually succeeded in killing plant lice with this preparation in the proportion of one gallon to each one hundred gallons of water. Thoroughness of application is of as much importance as the strength of material used.

Nikoteen is a more concentrated abstract, 1 part being used with from 400 to 600 parts of water.

Black Leaf 40 is a concentrated solution of nicotine-sulphate and is widely and successfully used in large western orchards, at the rate of 1 part to 800 or 900 parts of water.

It is the common practice to add soap,—whale oil soap or good laundry soap at the rate of 2 bars to 50 gallons. This is to lessen the formation of drops, causing the spray to cover surfaces more in the form of thin film.

Better success is obtained by some by using a little lime instead of soap, the inert solid in suspension aiding the extract to "wet" and "stick" to the bodies of the aphids. For this purpose 1 pound of stone lime, slaked and strained into 50 gallons of tobacco extract as prepared for application, is sufficient.

Formula B.—Kerosene Emulsion.

Hard Soap	1-2 pound
Boiling Water	1 gallon
Kerosene	2 gallons

To prepare dissolve one-half pound of soap in one gallon of soft water by boiling; when well dissolved and still boiling hot, remove from the fire and add two gallons of kerosene, and agitate at once as briskly as possible. The emulsion is more readily made if the kerosene first be heated by immersing the vessel containing it in a larger vessel of boiling water. *Never* heat the kerosene over a direct fire.

If large quantities are being made, a good way to emulsify is to use a force pump and spraying nozzle and pump the mixture as forcefully as possible back into the vessel containing it. If the emulsion is properly formed, the whole mass will appear much like whipped cream and will mix readily in water without a film of oil rising to the top.

As soon as emulsified, add twenty-seven gallons of water and use at once. This will make thirty gallons of the mixture, and such an emulsion will be one-fifteenth oil (or a 7 per cent emulsion). This is the strength ordinarily used for the destruction of insects upon plants. For larger or smaller quantities, prepare in the same proportions.

Sometimes the emulsion is not perfect and a little oil rises to the top. In such cases, if the last in the barrel or tank is pumped out upon the

foliage, it is likely to burn it. So it is advisable, unless the emulsion is of good quality, to throw out the last few gallons, making no use of it.

It is best to dilute and apply kerosene emulsion as soon as it is prepared.

Avoid using alkali or any hard water in making the emulsion, as it will cause the oil to separate and rise to the top. Any clean, soft water will usually give good results.

Formula C.—Miscible Oils.

There are several miscible oils upon the market which may be added directly to water forming a milky emulsion at once. In the preparation of any of these, such as "Scalecide," or "Target Brand Scale Destroyer" or "Killoscale," add the oil directly to the water with a little stirring. One gallon of the miscible oil in 30 to 50 gallons of water will make a mixture, which in most cases will be strong enough to kill plant lice, if thoroughly applied.

Formula D.—Whale-oil or Fish-oil Soaps.

The so-called whale-oil or fish-oil soaps which are quite extensively used for the destruction of plant lice, will usually be effective if thoroughly applied in the proportion of one pound of the soap to each six or eight gallons of water There are numerous brands of these soaps upon the market. Among those that have been used quite successfully are Good's Whale-Oil Soap and Bowker's Tree Soap.

* * * * * * * * * * *

In recent years tobacco extracts have rapidly taken the place of other remedies for aphids, and well informed apple growers are using them almost to the exclusion of other insecticides. It should be remembered that this is a contact insecticide and kills only the insects actually touched. It is, therefore, necessary to be very thorough in the spraying.

FIG. 67. Southern leaf curl, migrants from which colonized apple seedling shown in accompanying figure.

FIG. 68. Seedling apple, photographed July 23, 1912 to show colony of woolly aphids which are the descendants of migrants from elm leaf curl (Fig. 67) received from Columbia, Missouri, May 12, 1912.

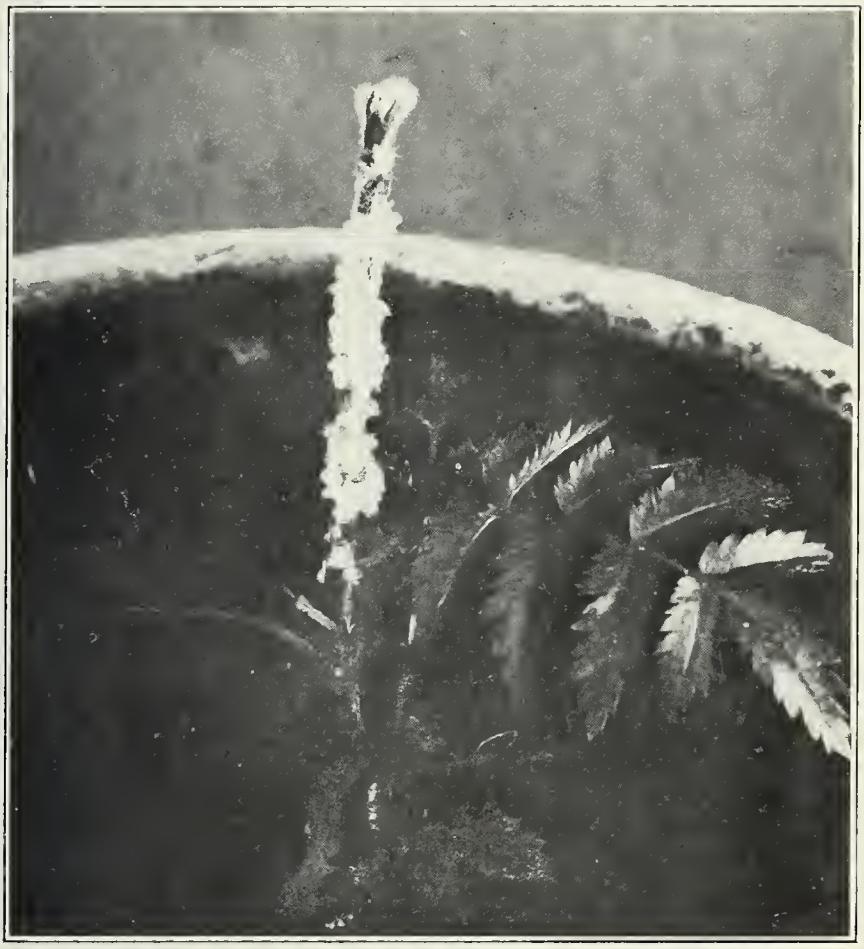


FIG. 69. Seedling mountain ash photographed June 25, 1913 to show colony of woolly aphids which are the progeny of migrants from elm leaf rosette caged with mountain ash, June 17, 1913. Two apterous generations matured on this seedling, but the third generation proved too much for the little tree which was so nearly dead by August 10 that the last of the aphid colony perished at that time.

The antenna of one of the winged progenitors of this colony is shown as Fig. 81.

FIG. 70. Young rosette photographed June 6, 1913. Small picture at right.

FIG. 71. Old rosette photographed July 17, 1913.

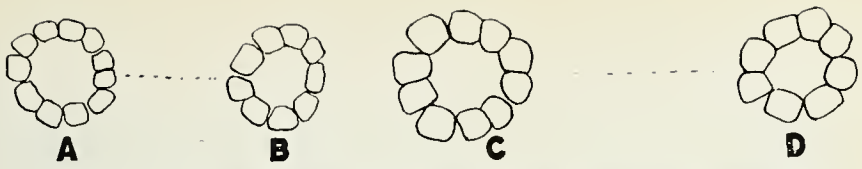
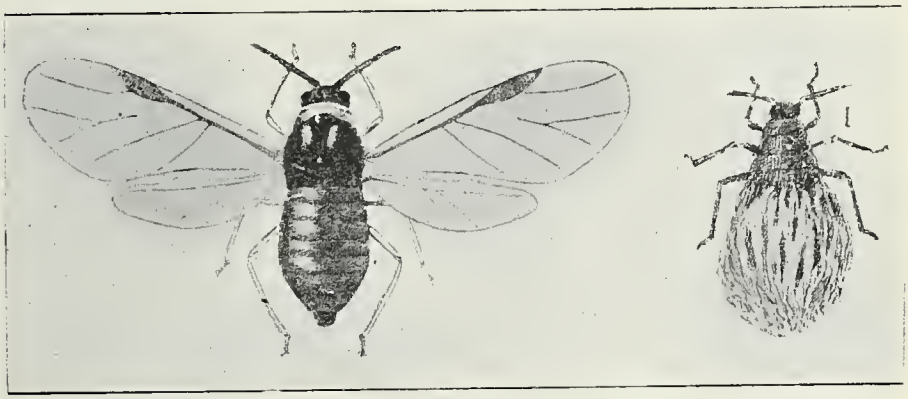
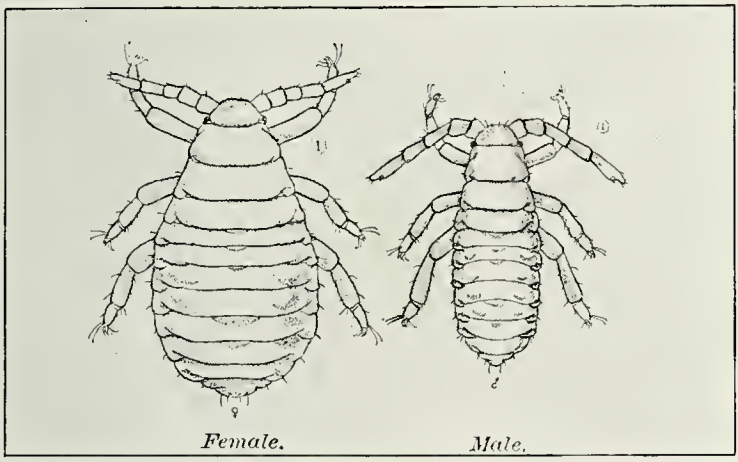


FIG. 72. Dorsal wax gland of rosette aphid, second generation. A & B, a pair on head. C & D, a pair on prothorax. Notice that the sections are not uniform in number as is often the case



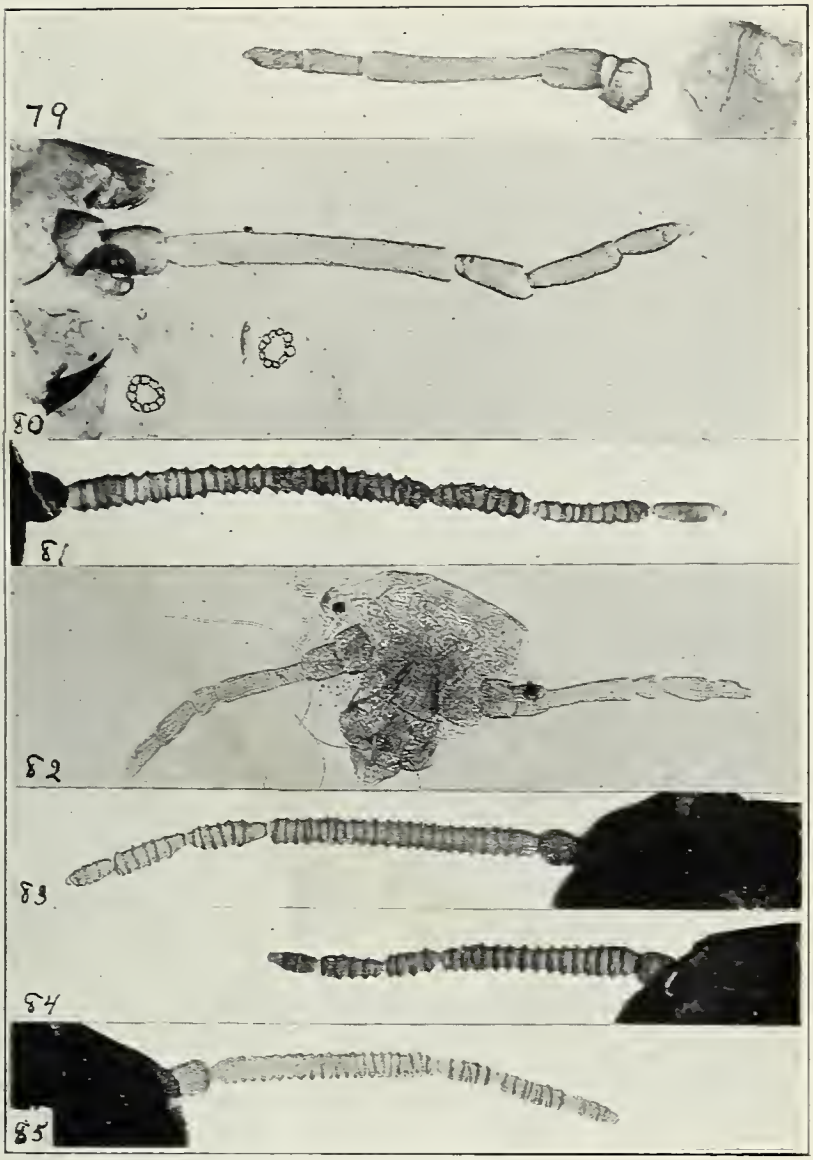
FIGS. 73 and 74. Woolly Aphid. Winged and wingless forms. Greatly enlarged (After Marlatt.)



FIGS. 75 and 76. Mature sexual individuals of the Woolly Aphid,—the oviparous female and male. Real size shown in circles at right of figures. (After Alwood.)

FIG. 77. Apple root, showing knotty growth caused by Woolly Aphid.

FIG. 78. Nymphs of the Woolly Aphid, *Schizoneura lanigera* on water shoot of mountain ash, *Pyrus americana*,—the immediate progeny of migrants from elm leaf rosette. Photographed at Orono, June 28, 1912. Enlarged.



Antennae of Woolly Aphid. Fig. 79—Stem mother from rosette June 5, 1913 (33-13); Fig. 80—Second generation, from rosette June 12, 1913; Fig. 81—Spring migrant from rosette and progenitor of summer generations on *Pyrus* (57-13); Fig. 82—Apterous viviparous form on apple bark (98-08); Fig. 83—Fall migrant from apple (115-06); Fig 84—Fall migrant from the bred colony shown in Fig. 68 (9-12 sub 1); Fig. 85—Fall migrant from *Crataegus*.